

Detail Synthesis for Image-based Texturing

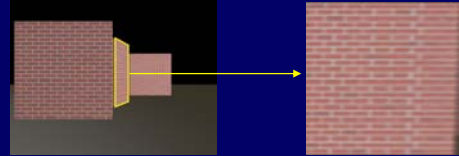
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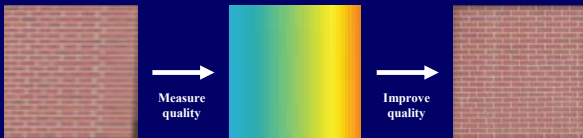
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Image-based Texturing (IBT)

- Resample images to create realistic surface textures
- IBT Problems:
 - Quality often poor, depends on viewpoint
 - > Blurry or stretched textures, caused by foreshortening and distance
 - Requires many images for reasonable quality
 - > Some camera angles impossible to obtain



Contributions



- Identify and measure texture quality degradation due to poor sampling
- Create textures with uniformly high resolution, using texture synthesis
- Benefits
 - Improves quality of image-based textures
 - > Preserves low frequency information
 - > Synthesizes only high frequency detail
 - Allows use of fewer images

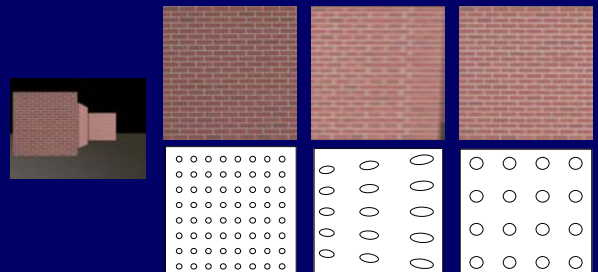
Related Work

- Image-based Texturing
 - Blending – [Neugebauer99], [Rocchini99], [Lensch00], [Bernardini01]
 - View-dependent Texture Maps – [Debevec96]
- Quality Metrics
 - Cosine Test – [Debevec96], [Rocchini00], [Lensch00]
 - Projected Pixel Area – [Ofek97], [Neugebauer99]
- Texture Synthesis
 - [Heeger95], [DeBonet97], [Efros99], [Wei00]
- Other
 - Image sharpening – [Freeman02]

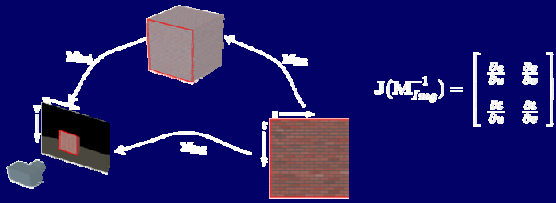
- Measuring texture quality
- Detail synthesis
- Results
- Future work and conclusions

What is Quality?

- Spatial frequencies which are captured accurately
- Missing frequencies (undersampling) results in loss of detail

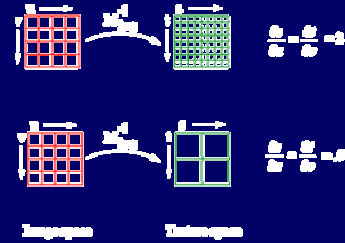


The Jacobian



- Describes sample distance in the world
- Physically-based, derived from scene geometry, camera calibration
- Captures directionality (anisotropy)

The Jacobian: An Example

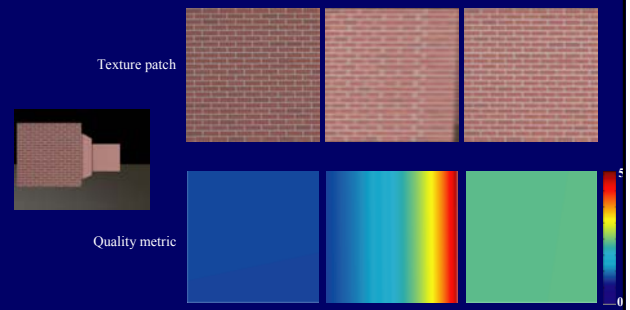


Our Jacobian Sampling Metric

- $\max(J)$ = largest of any value in Jacobian matrix
 - $\max(ds/du, ds/dv, dt/du, dt/dv)$
- Conservative
 - Largest sample distance to avoid overestimating captured frequencies
- Anisotropic
 - Accounts for rotation introduced by the imaging transform

Measuring Sampling

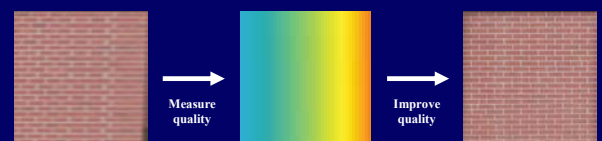
- Ability to detect and flag poor or missing data



- Sampling metric
- Detail synthesis
- Results
- Future work and conclusions

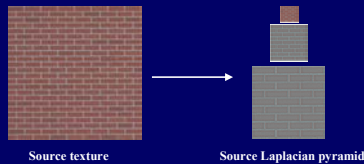
Detail Synthesis Overview

- Metric identifies regions of poor quality
- Use metric to synthesize high frequency texture detail
 - Pixel-based synthesis algorithms used as black box
 - Use all existing data instead of starting from scratch



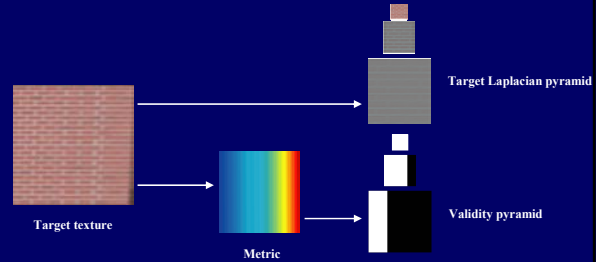
Detail Synthesis (1)

- Start with a 'good' source texture
 - 'Good' identified by metric
 - Create a Laplacian pyramid



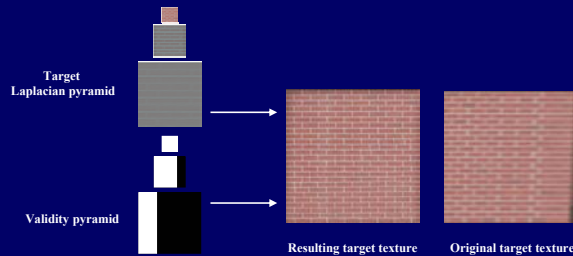
Detail Synthesis (2)

- For the 'bad' target texture
 - Create a target pyramid
 - Metric identifies valid data at each level of target pyramid

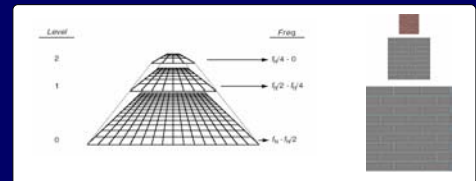


Detail Synthesis (3)

- Use standard texture synthesis algorithms
 - Synthesize *only* missing detail in target
 - Makes the target texture as good as the source.



Laplacian Pyramids



- Laplacian pyramids are (approximately) band-pass
- Levels correspond to sampling rate octaves
- $\text{Max}(J) = \text{sample distance}$, $\log(\text{Max}(J)) = \text{pyramid level}$

Pyramids and Sampling

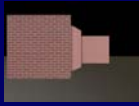
- Sampling rate = $1 / \text{sample distance}$
- Nyquist frequency = $.5 * \text{sampling rate}$ cycles / pixel
 - f_n for a given texture is captured at sampling rate = 1
- Level 0 (bottom) $f_n > f \geq f_n / 2 \rightarrow$
 - $1 < \text{sample distance} \leq 2.0$
 - log maps to pyramid level.
- Level 1 $f_n / 2 > f \geq f_n / 4 \rightarrow$
 - $2.0 < \text{sample distance} \leq 4.0$
 - log maps to pyramid level

Putting it all together

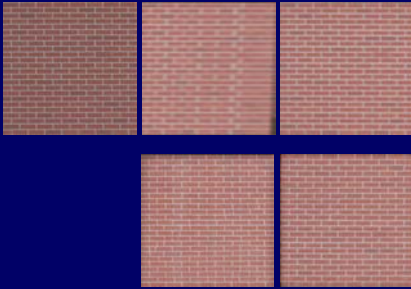
- Use metric to determine the source texture
- Use metric to measure sampling over all bad textures
 - Identifies valid and invalid regions
- Synthesize missing detail in target textures

Results – Brick Cubes

Original texture



Synthesized texture



Results – Ho Plaza



Original texture



Synthesized texture

Results – Moroccan Doors

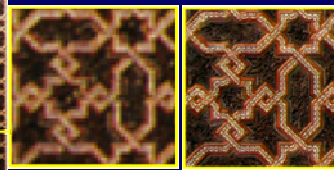
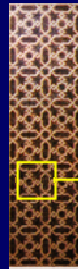


Original texture



Detail (source) texture

Results – Moroccan Doors



Original texture



Synthesized texture

- Sampling metric
- Guided detail synthesis
- Future work and conclusions

Conclusion

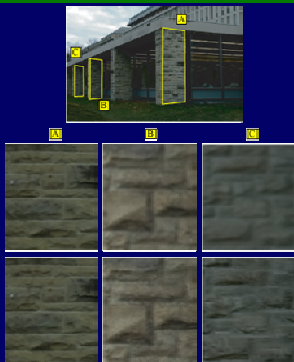
- Jacobian-based measure of sampling quality
 - Accounts for all geometric factors affecting the sampling rate
 - Provides quantitative measure of degradation due to sampling
- Detail synthesis
 - Use Jacobian metric to measure texture quality
 - Synthesizes only missing detail, where required
- Benefits
 - Enables creation of uniform, high resolution textures
 - Significantly reduces image collection burden to the user

Future Directions

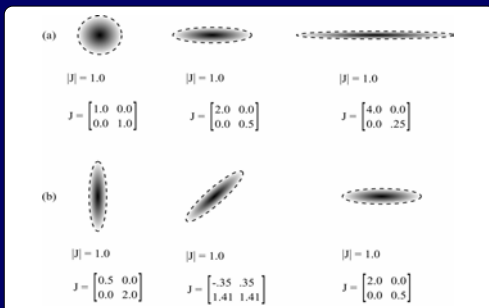
- Utilize complete Jacobian matrix
 - Take advantage of image representations capture directionality
- Extend to situations without perfect source texture
- Examine relationship to patch-based synthesis approaches

Questions?

Results – Olin Library



$J(M)$ vs. $|J(M)|$



Test Scene

